Membrane Transport

Chapter 5.2-5.4

Biol 1A

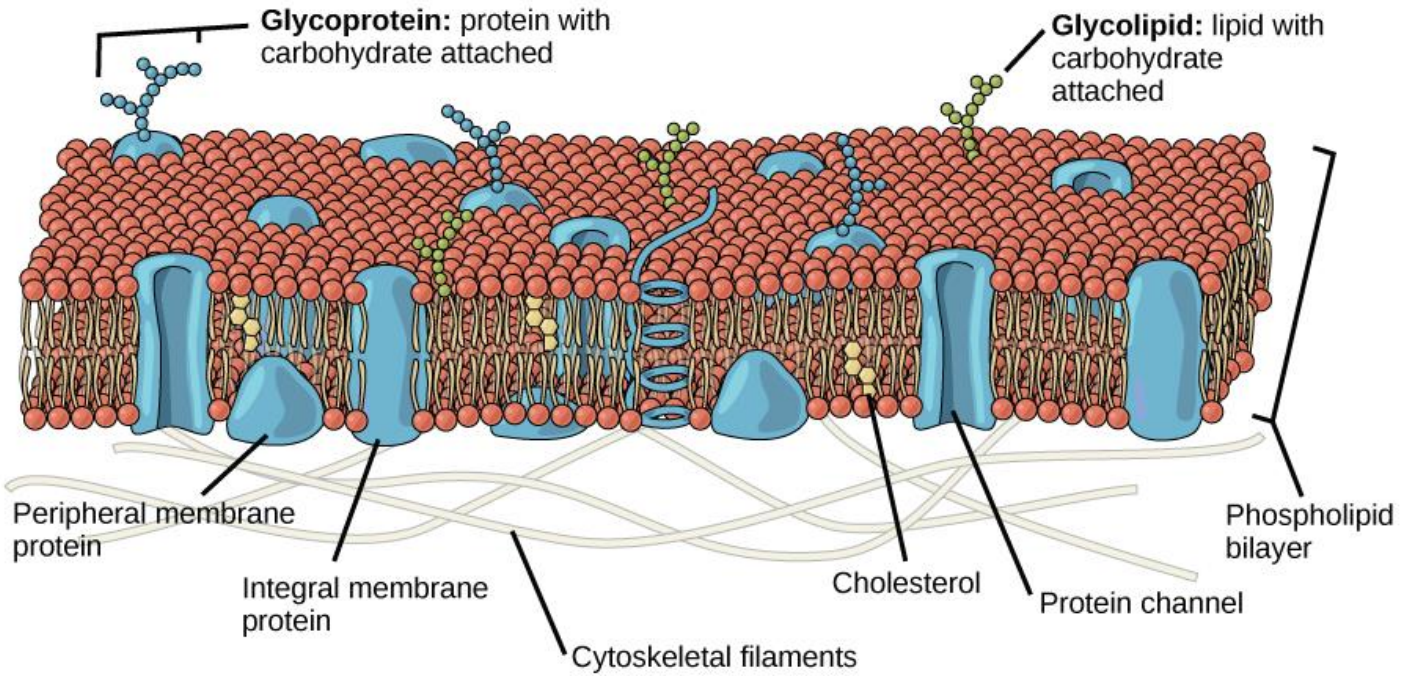
California State University, Fresno

Learning Goals

1. Understand the semi-permeability of the plasma membrane
2. Define diffusion and osmosis.
3. Describe how molecules move across the plasma membrane.
4. Describe the mechanisms of active transport across the plasma membrane.
5. Describe the process of endo- and exo-cytosis.

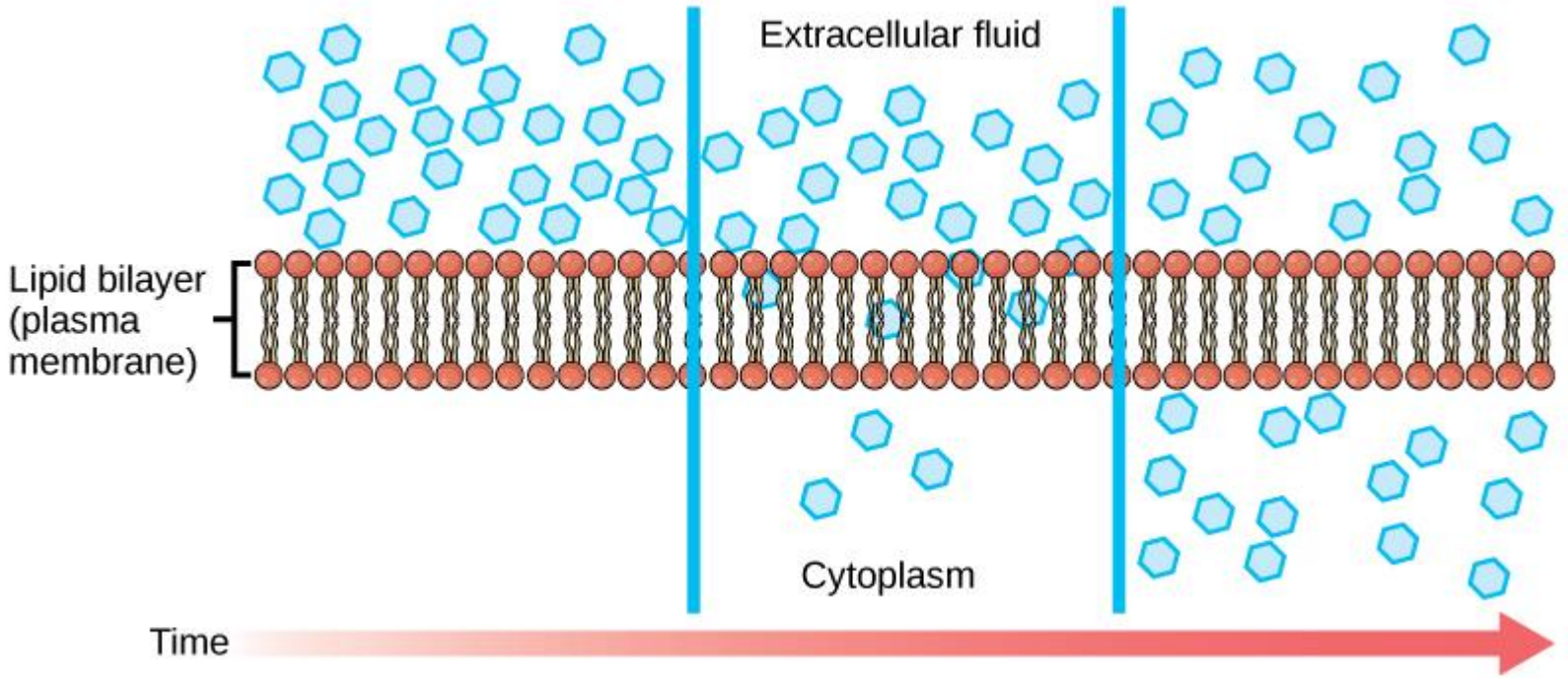
Passive Transport

- **Passive transport** is a naturally occurring phenomenon and does not require the cell to exert any of its energy to accomplish the movement.
- In passive transport, **substances move from an area of higher concentration to an area of lower concentration**



Diffusion

- Some materials move through the plasma membrane by diffusion.
- Diffusion expends no energy.
- **Small, nonpolar molecules can diffuse directly across the plasma membrane (e.g. CO_2, O_2)**

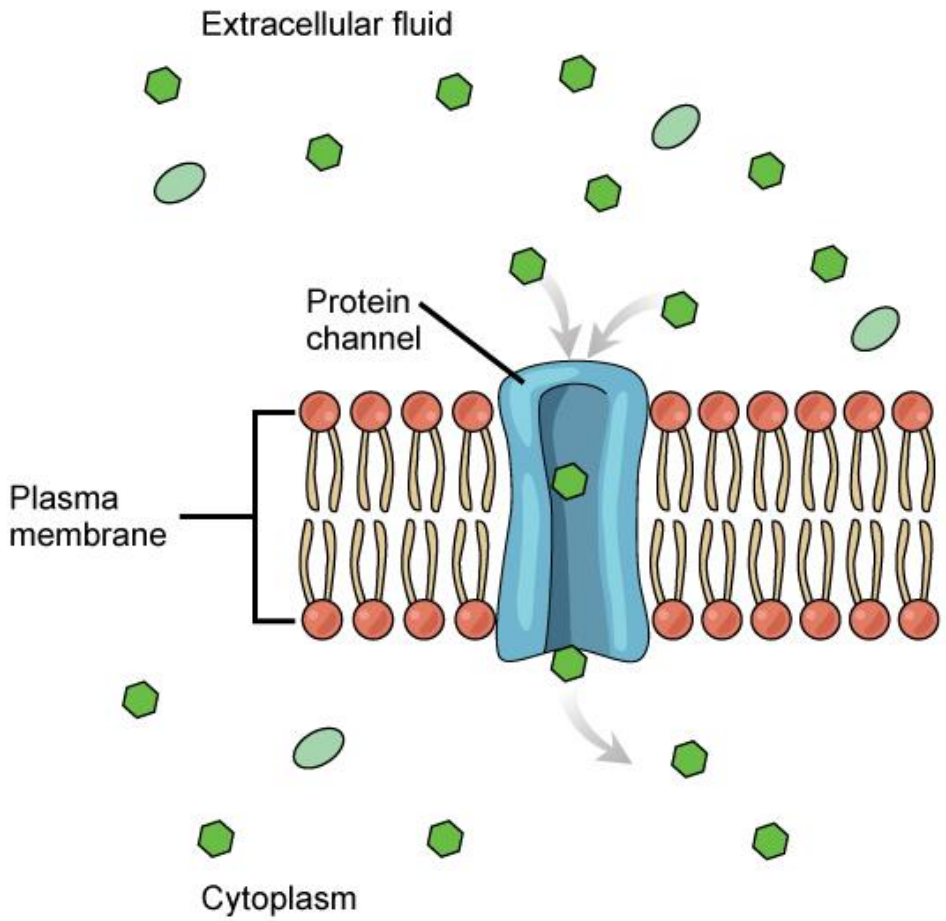


Facilitated transport (diffusion)

- Facilitated transport requires **transport proteins** which provide a means for larger and/or polar molecules to move across the membrane
- They can function as either **channels** for the material or **carriers**.
- This process still does not require any additional energy.
- Molecules diffuse from high to low concentration with the aide (facilitation) of transport proteins

Channels

Channels are specific for the substance that is being transported. Channel proteins have hydrophilic domains expose to the intracellular and extracellular fluids; they additionally have a hydrophilic channel through their core that provides a hydrated opening through the membrane layers.

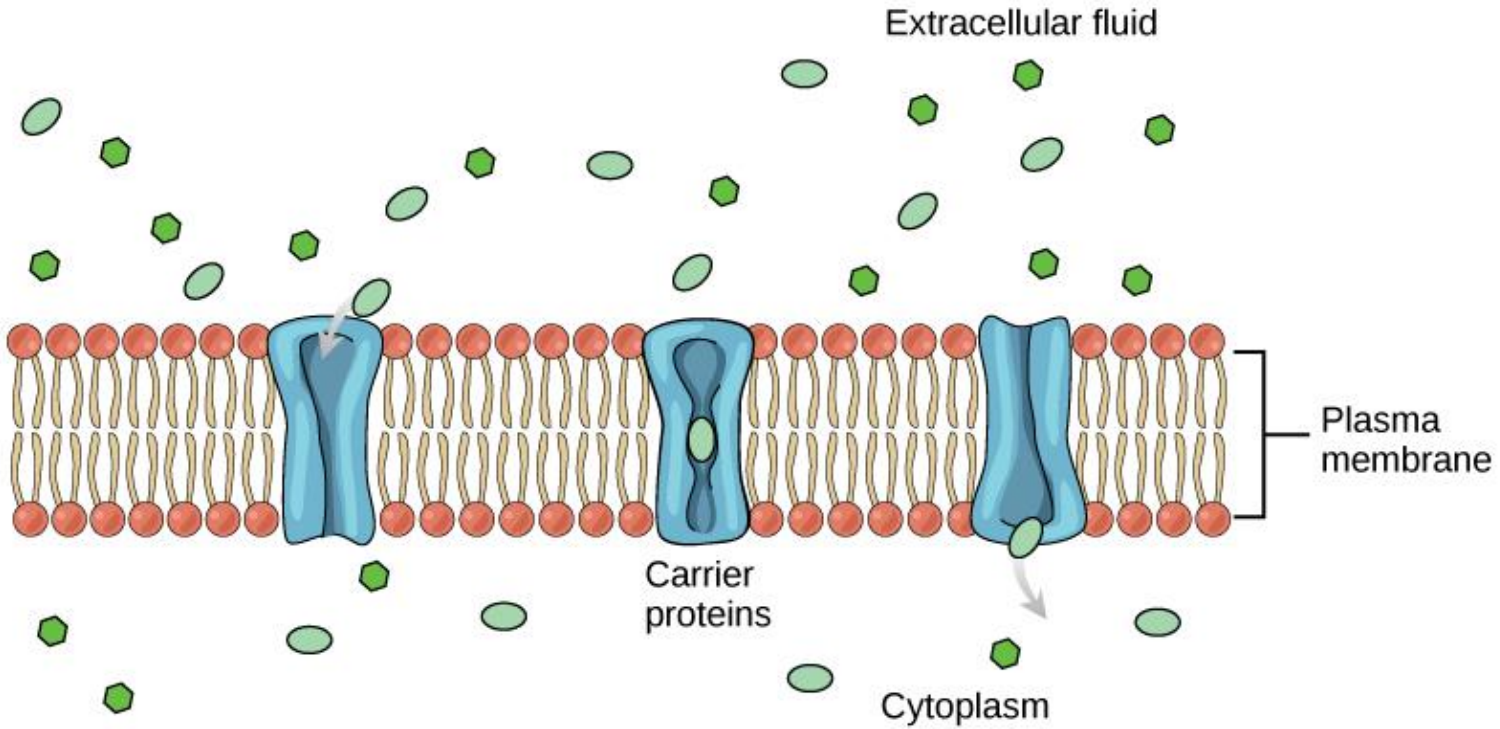


Aquaporins are channel proteins that allow water to pass through the membrane at a very high rate.

Carrier Proteins

1. Bind a substance
2. Triggers a change of its own shape
3. Moving the bound molecule down its concentration gradient

- Each carrier protein is specific to one substance.

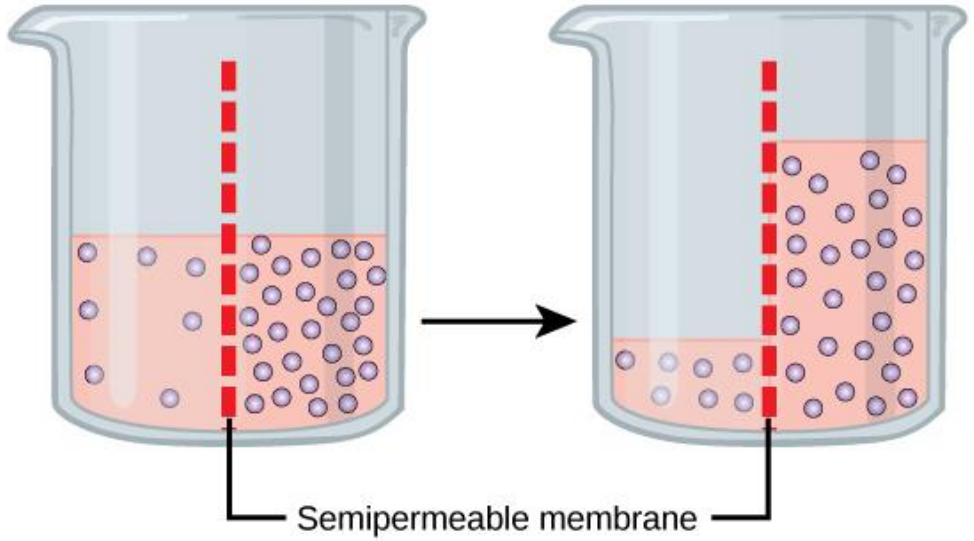


Osmosis

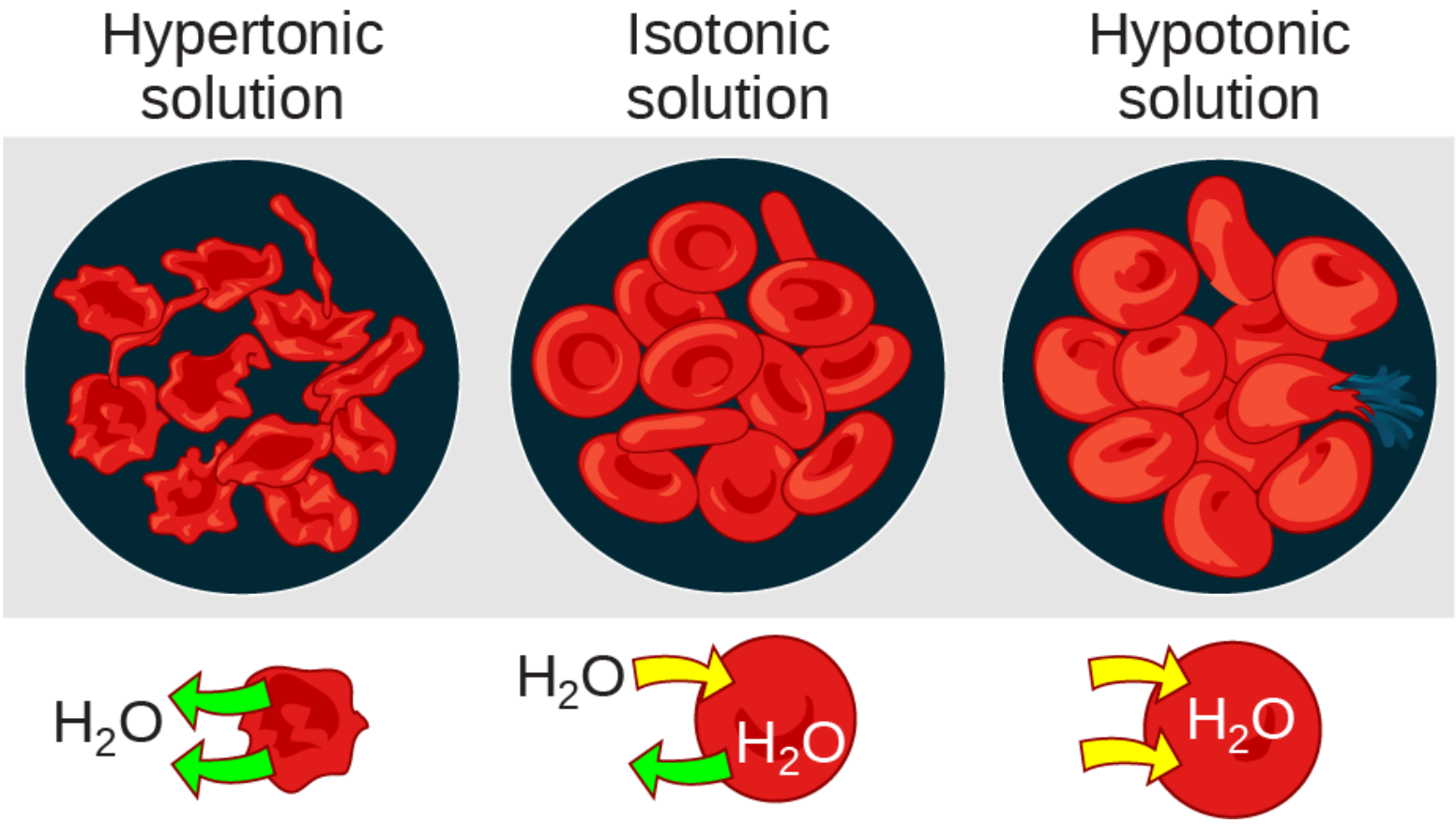
- Osmosis is the diffusion of water through a semipermeable membrane down its concentration gradient

- Water moves from
  low solute concentration -> high solute concentration
  high water concentration -> low water concentration

- **Aquaporins** facilitate water movement

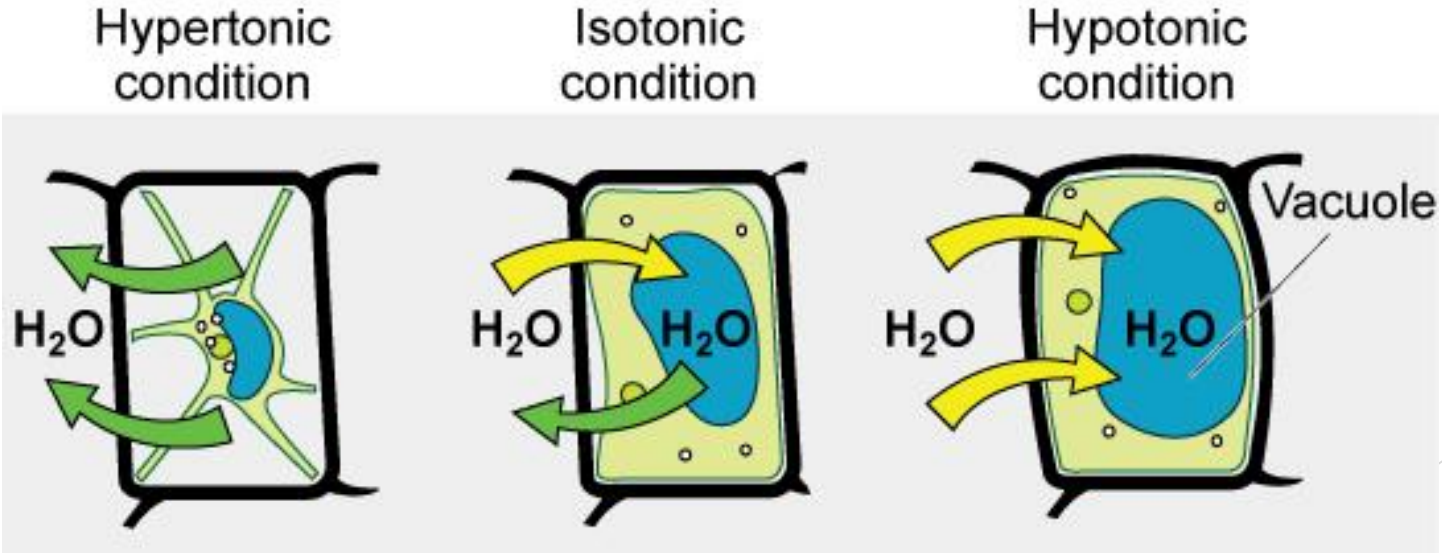


Tonicity


Hypertonic solution
Isotonic solution
Hypotonic solution
H_2O
H_2O
H_2O
H_2O

Tonicity in Living Systems

- The plasma membrane can only expand to the limit of the cell wall, so the cell will not lyse.
- **The cytoplasm in plants is always slightly hypertonic** to the cellular environment, and water will always enter a cell if water is available. This inflow of water produces **turgor pressure**, which stiffens the cell walls of the plant.



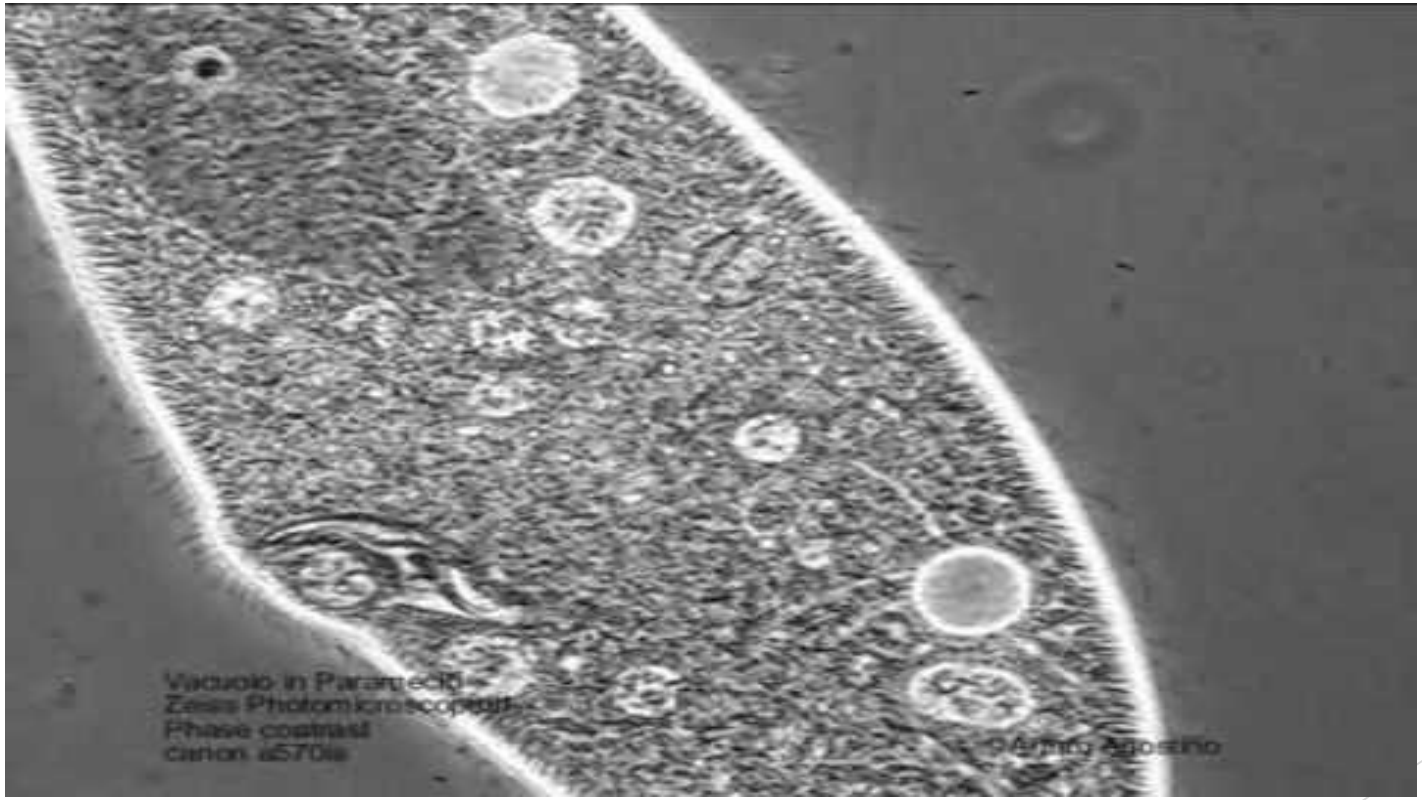
Turgor Pressure

- In non-woody plants, turgor pressure supports the plant. Conversely, if the plant is not watered, the extracellular fluid will become hypertonic, causing water to leave the cell.

- In this condition, the cell does not shrink because the cell wall is not flexible. However, the cell membrane detaches from the wall and constricts the cytoplasm. This is called **plasmolysis**. Plants lose turgor pressure in this condition and wilt.

Tonicity in Living Systems

- Tonicity is a concern for all living things.
- Paramecium and amoebas, which are protists that lack cell walls, have **contractile vacuoles**.



Active Transport

- Active transport mechanisms require the use of the cell's energy, usually in the form of adenosine triphosphate (ATP).
- If a substance must move into the cell against its concentration gradient—the cell must use energy to move the substance.
- Some active transport mechanisms move small-molecular weight materials, such as ions, through the membrane. Other mechanisms transport much larger molecules.

Moving Against a Gradient

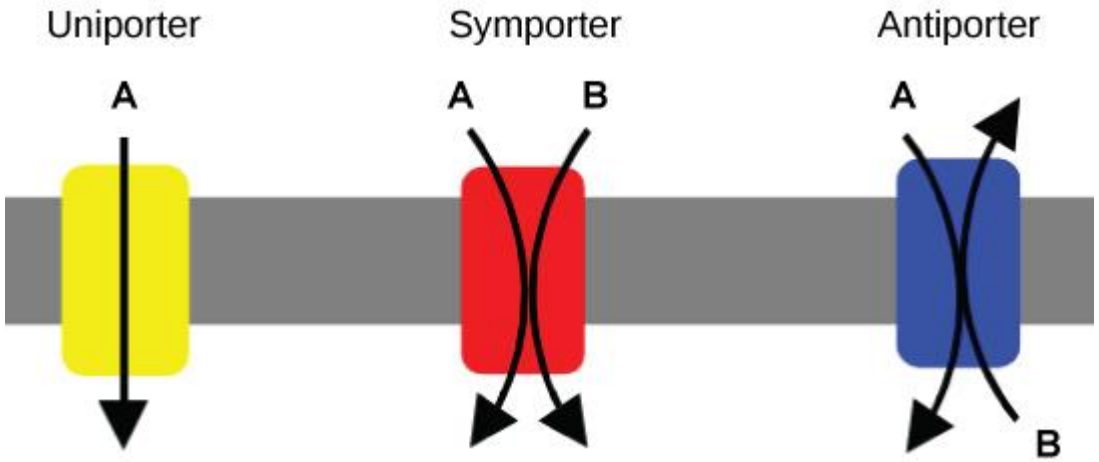
- Active transport mechanisms, collectively called **pumps**, work against electrochemical gradients.

- **Primary active transport** moves ions across a membrane and creates a difference in charge across that membrane, which is directly dependent on ATP.

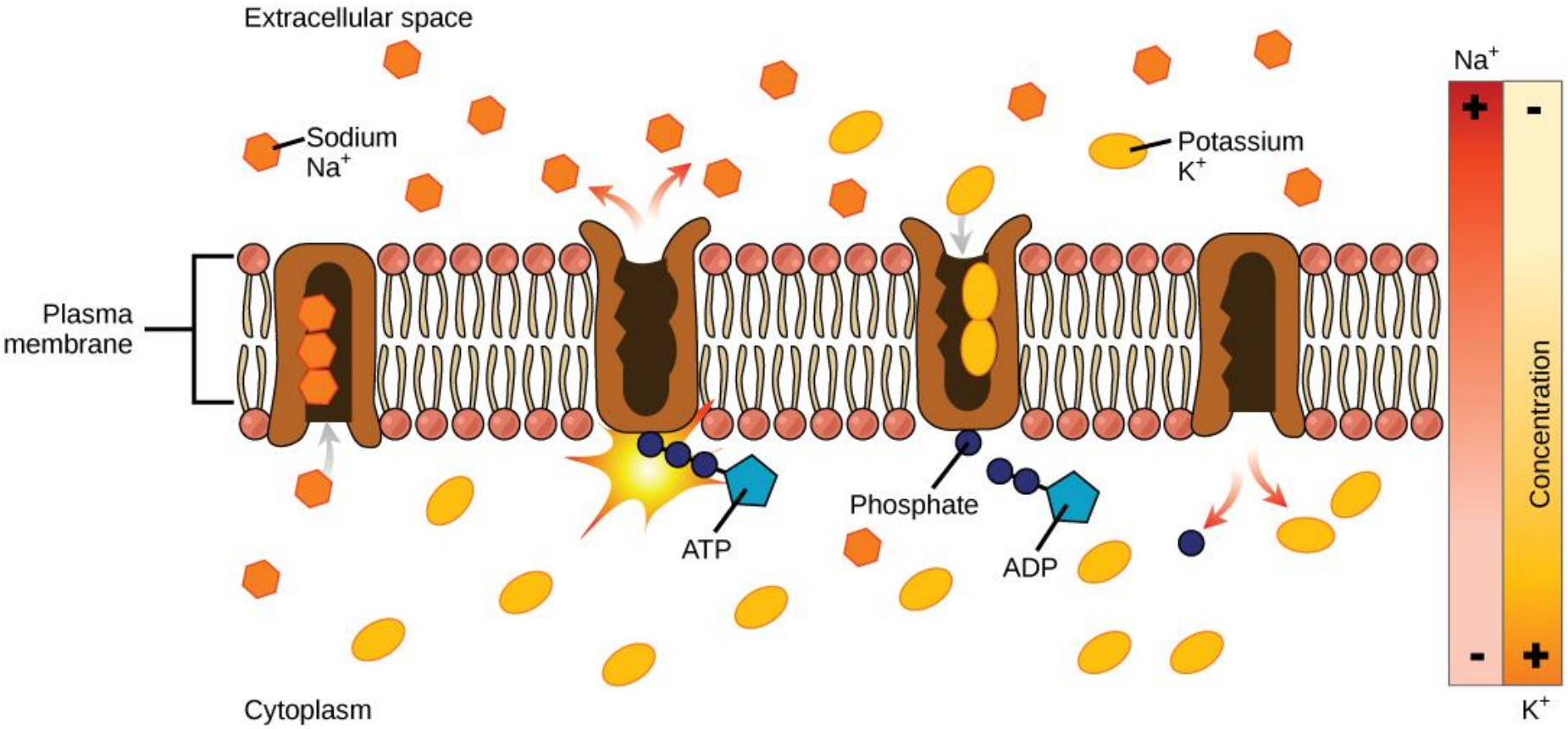
- **Secondary active transport** describes the movement of material that is due to the electrochemical gradient established by primary active transport that does not directly require ATP.

Carrier Proteins for Active Transport

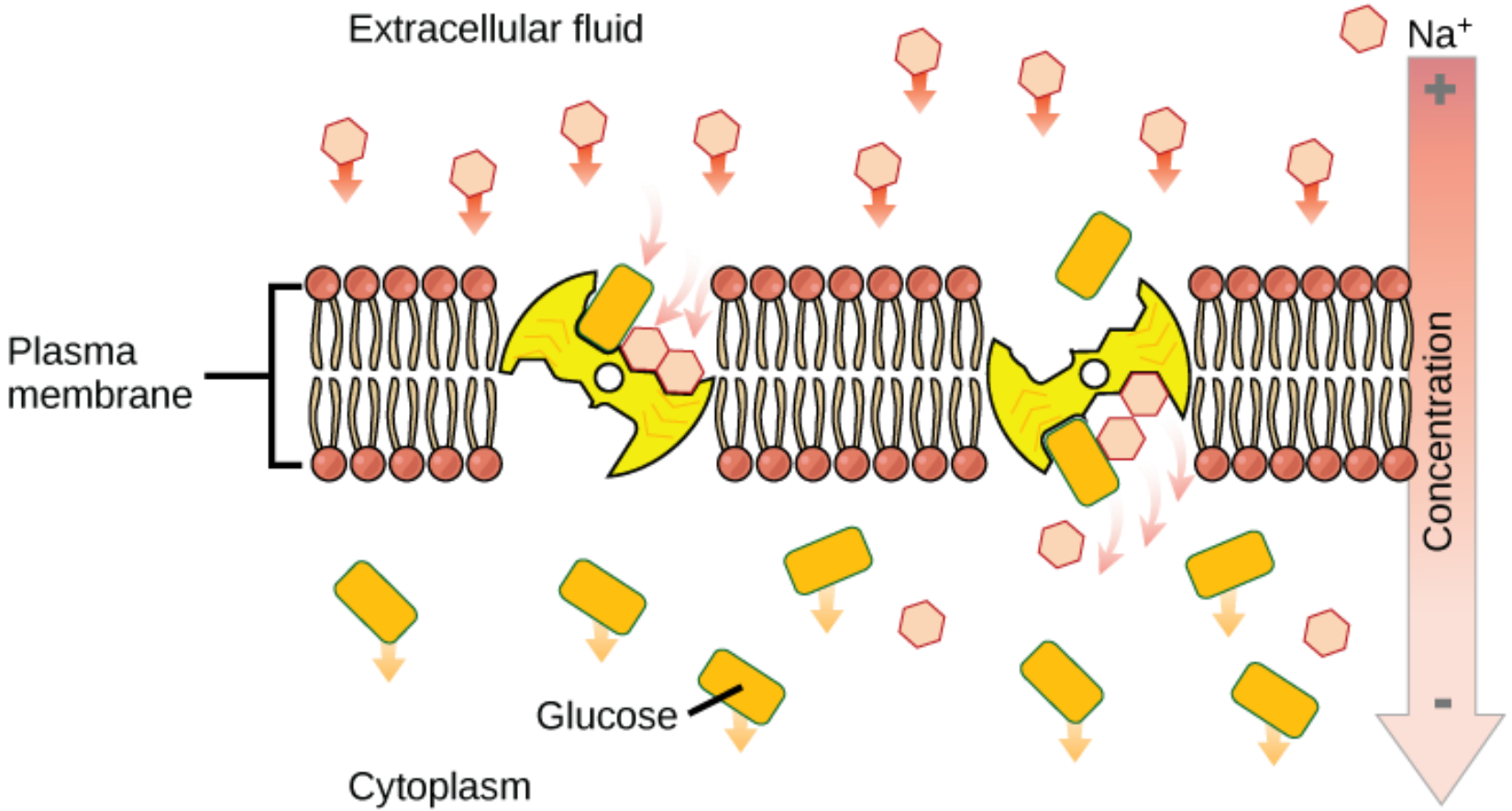
- A **uniporter** carries one specific ion or molecule.
- A **symporter** carries two different ions or molecules, both in the same direction.
- An **antiporter** also carries two different ions or molecules, but in different directions.



Primary Active Transport



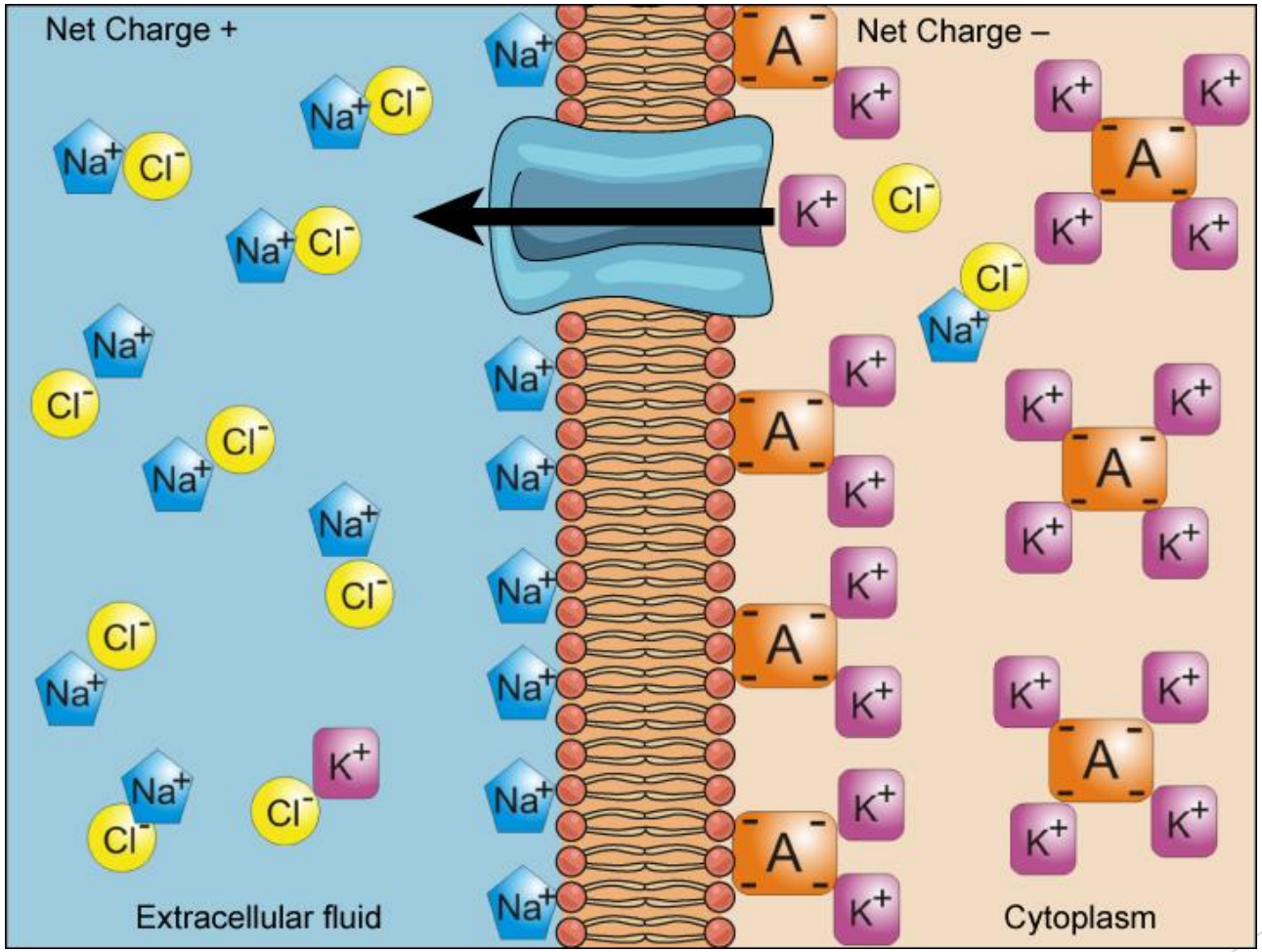
Secondary Active Transport (Co-transport)



Electrochemical Gradient

- There is a difference of charge, across the plasma membrane.

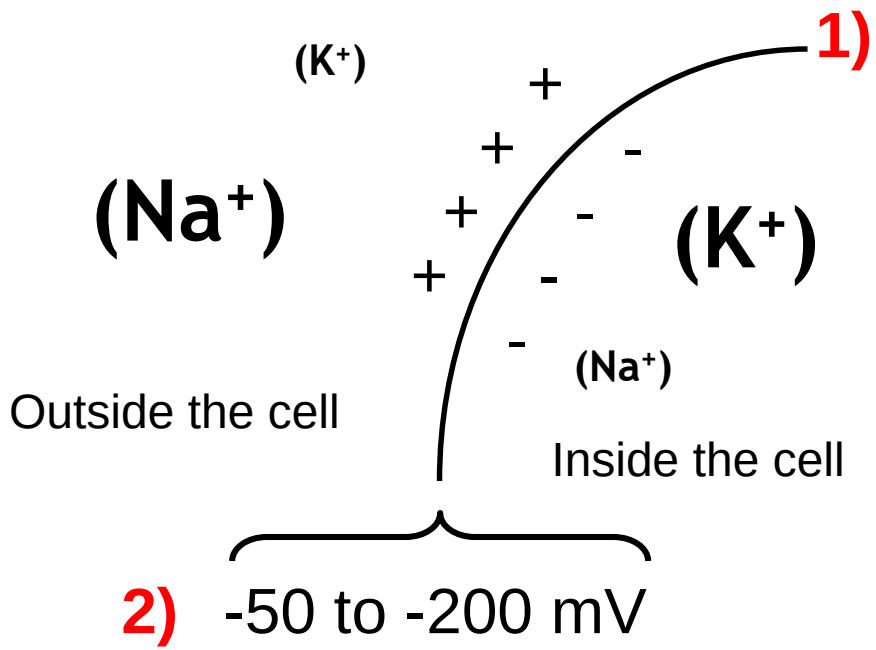
Low [K+]
High [Na+]



High [K+]
Low [Na+]

Ion Pumps Maintain Membrane Potential

- Membrane potential is the voltage difference across a membrane
- Voltage is created by differences in the distribution of positive and negative ions between the inside and outside of the cell



Because of unequal distribution of anions (-) and cations (+) on opposite sides of the membrane the inside of the cell is negative in charge compared to the outside.

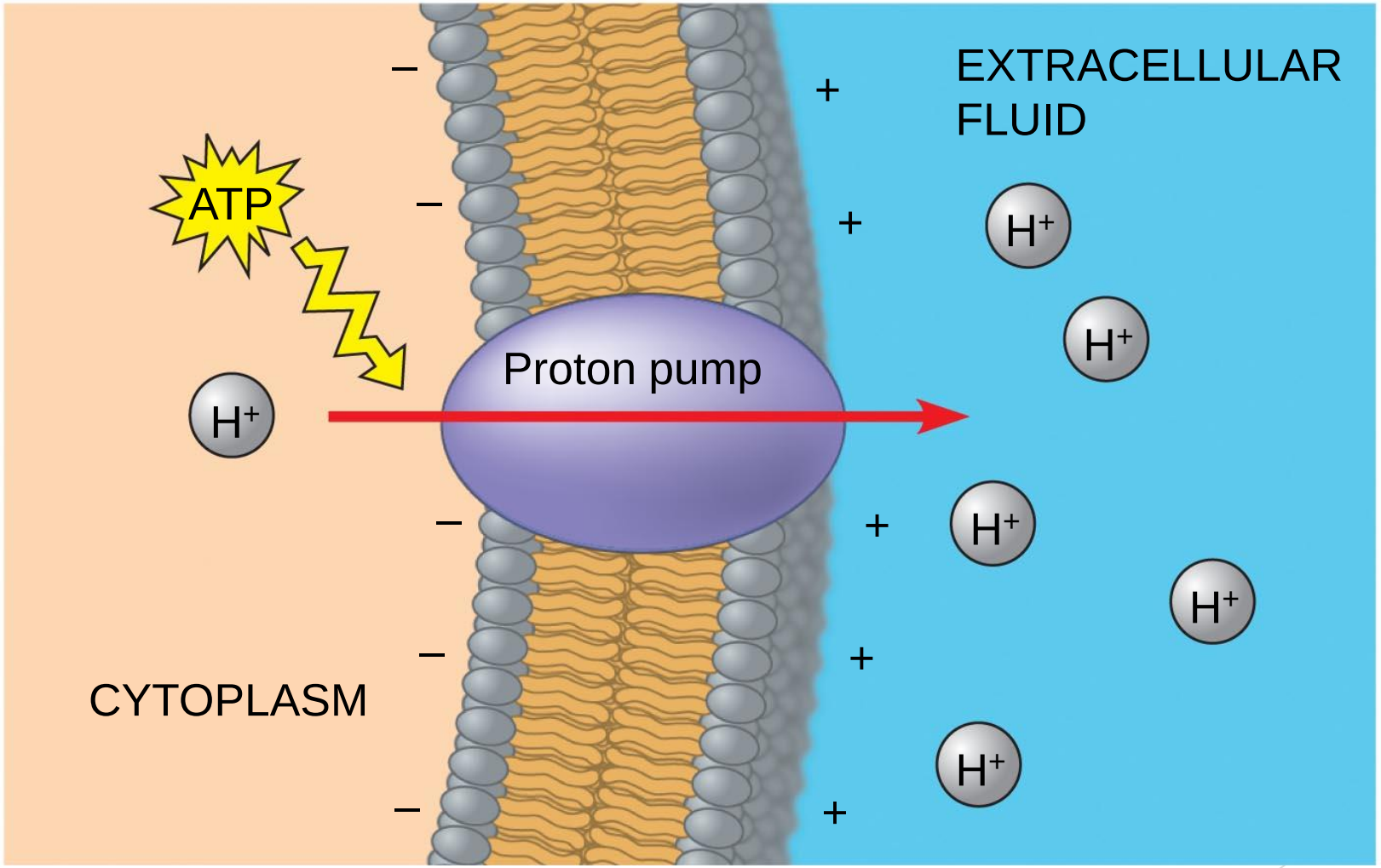
Two forces drive diffusion of ions across membranes:

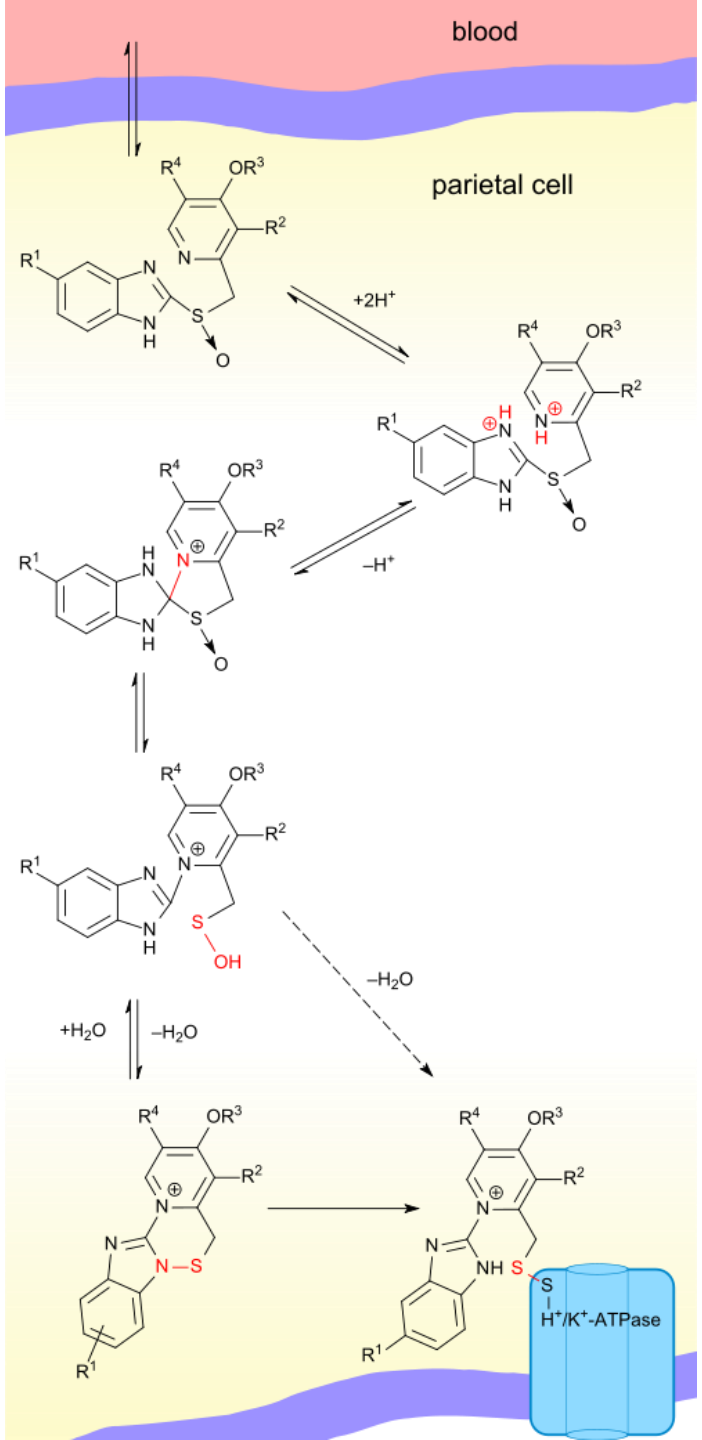
Two forces drive diffusion of ions across membranes:

1) **A chemical force:** the concentration gradient of the ion. Ions diffuse down their concentration gradients

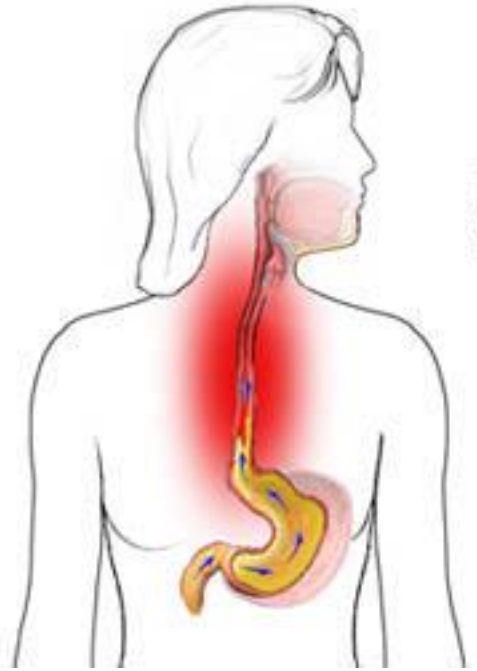
2) **An electrical force:** the effect of the ion's charge and the membrane potential effect on the ions movement.

proton pumps lower extracellular pH





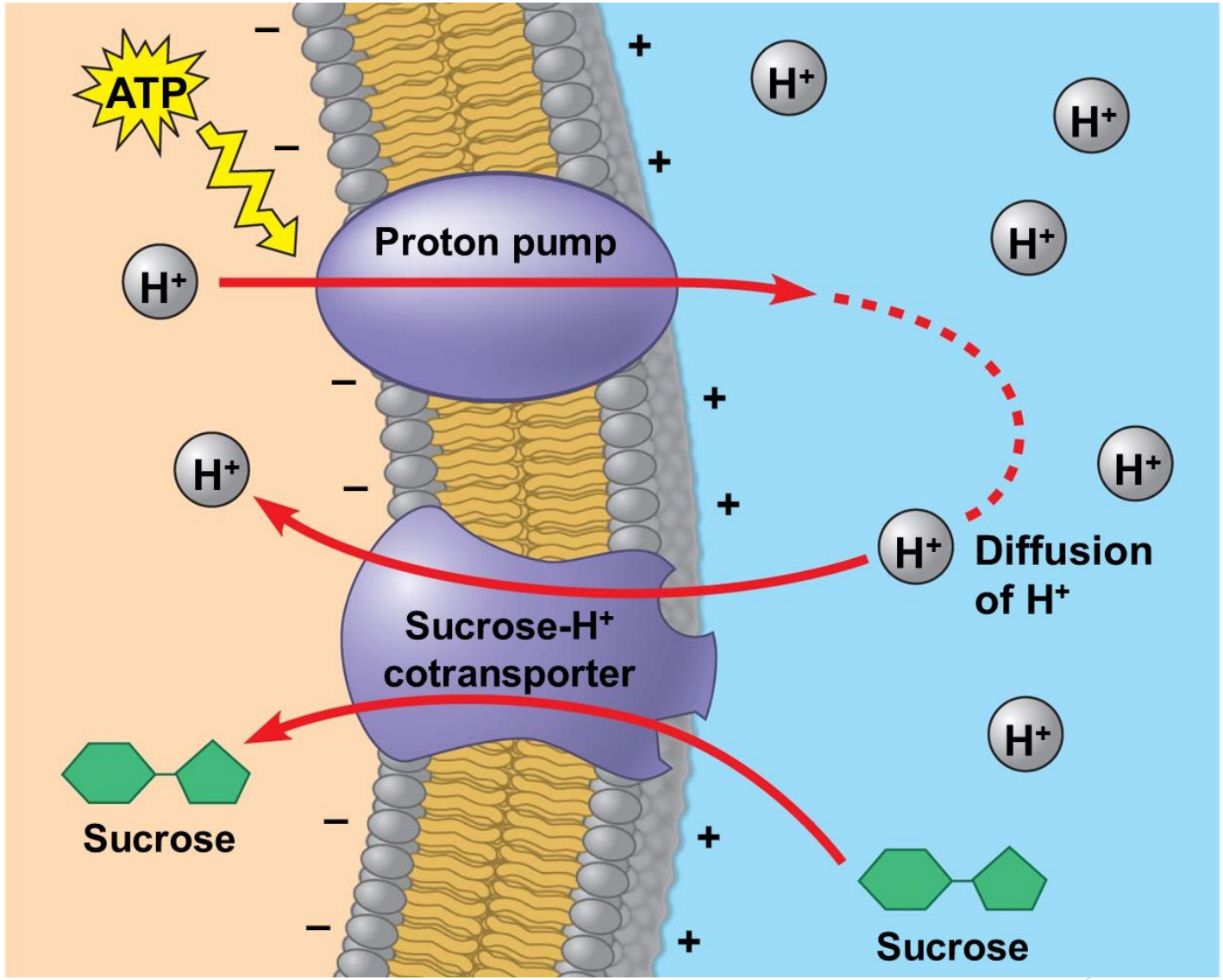
treatments for GERD, heartburn inhibit proton pumps (GERD = gastro-esophageal reflux disease)



Burning sensation in the chest and throat

treatments for GERD, heartburn inhibit proton pumps (GERD = gastro-esophageal reflux disease)

an electrochemical gradient can be used to do work

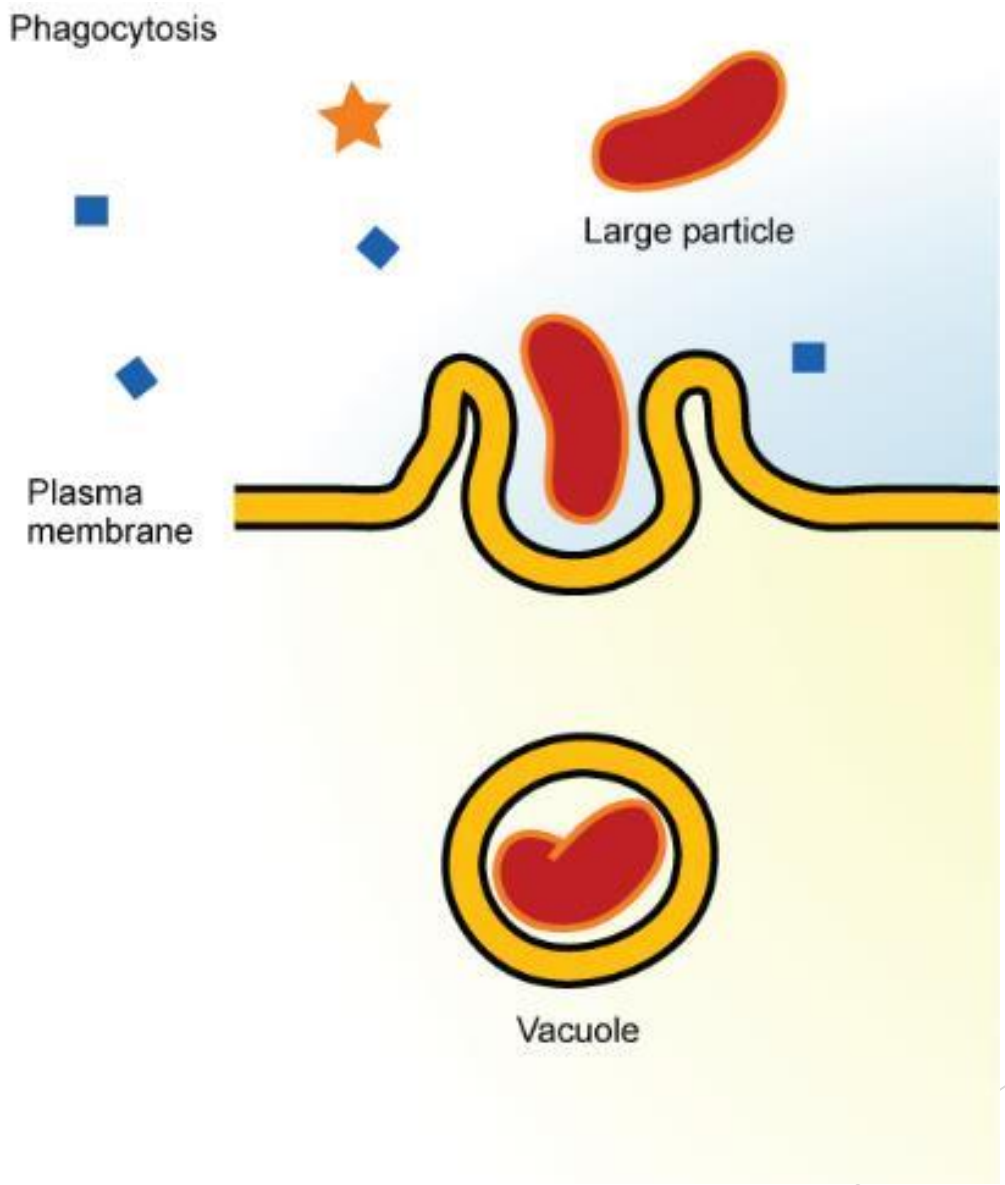


Movement of Large Molecules

- small molecules: through lipid bilayer or with transport proteins
- large molecules: uses membrane vesicles – requires energy
  - exocytosis
  - endocytosis – three types

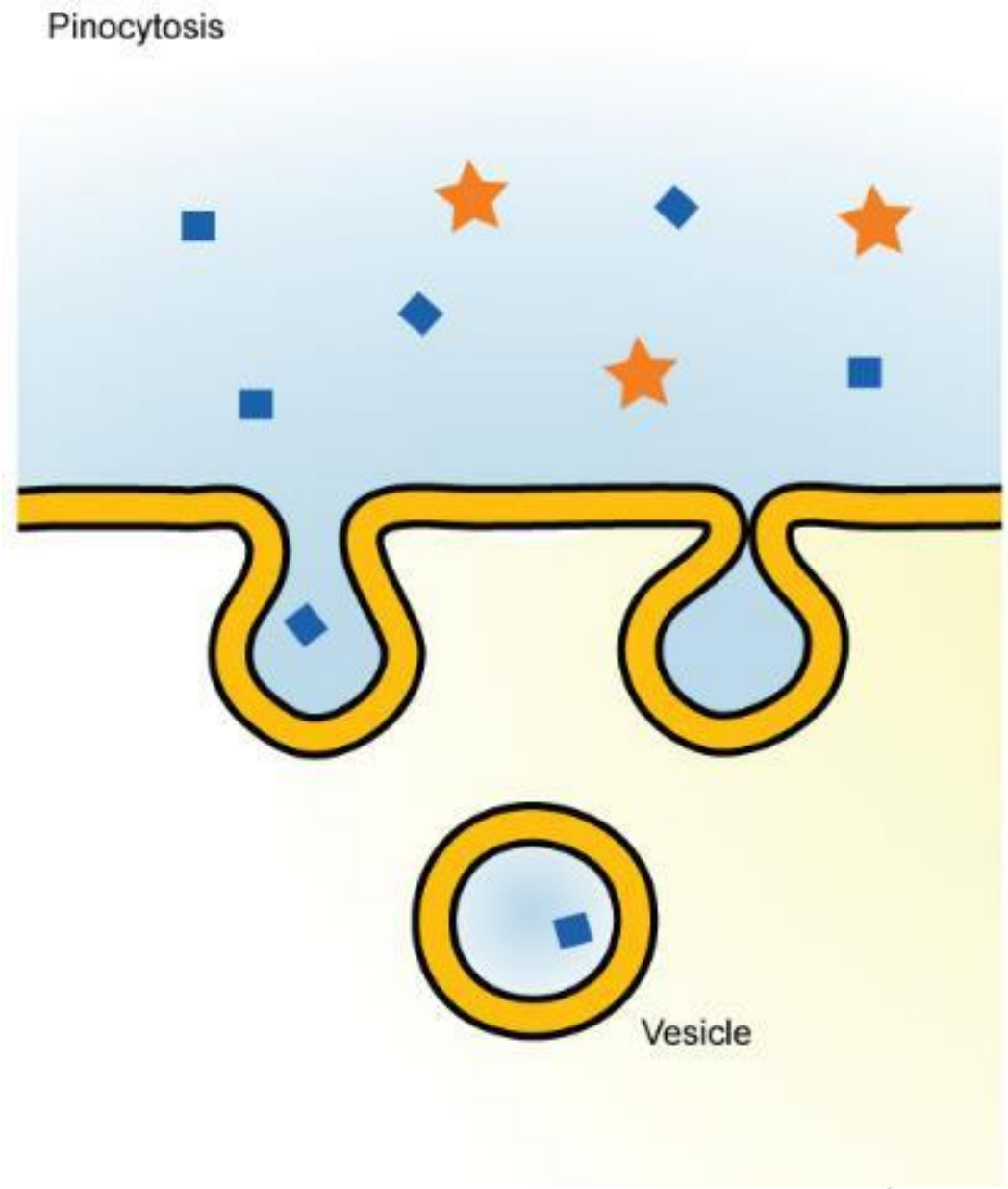
Phagocytosis

phagocytosis, the cell membrane surrounds the **particle** and engulfs it.



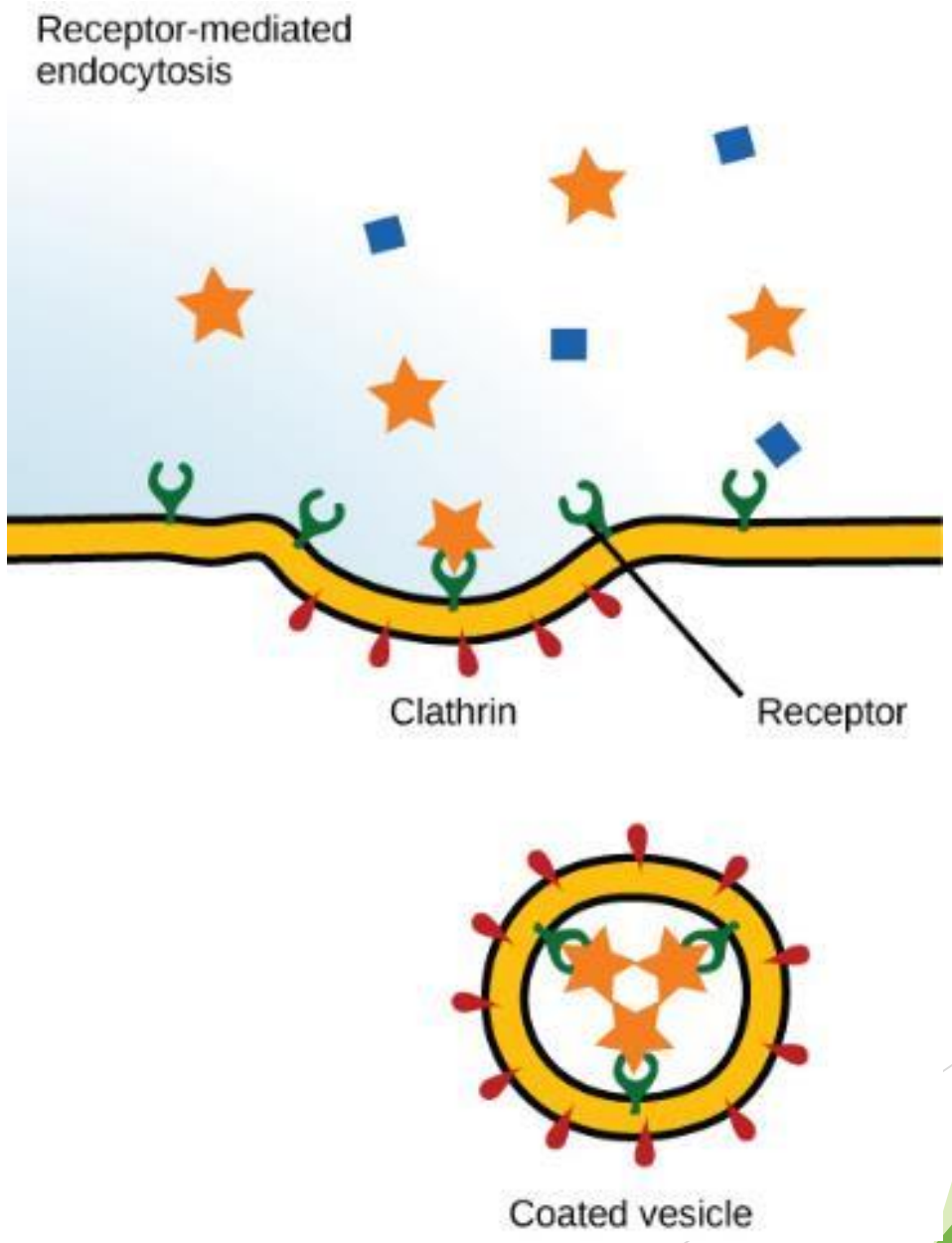
Pinocytosis

In pinocytosis, the cell membrane invaginates, surrounds a **small volume of fluid**, and pinches off



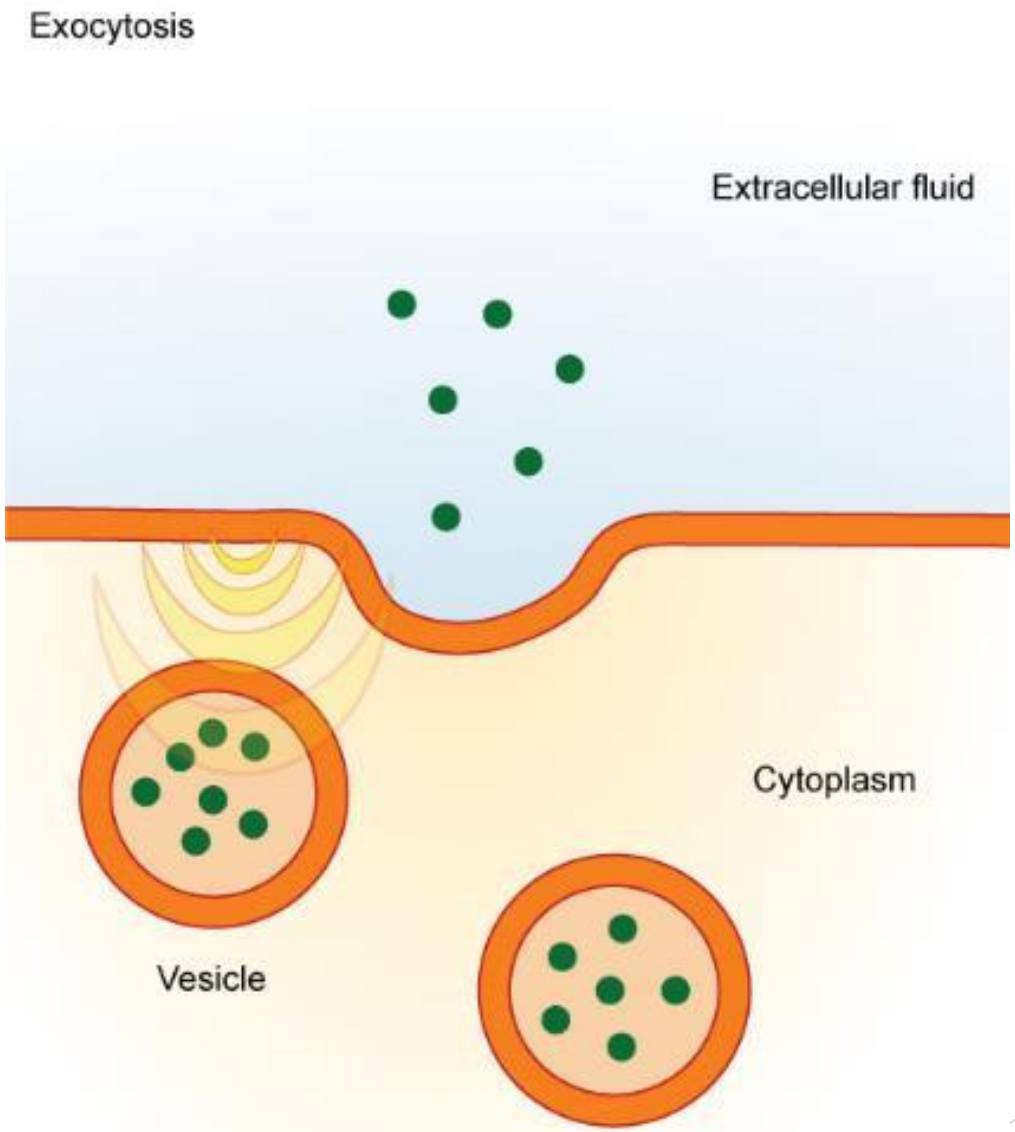
Receptor-mediated Endocytosis

In **receptor-mediated endocytosis**, uptake of substances by the cell is targeted to a single type of substance that binds to the receptor on the external surface of the cell membrane.



Exocytosis

In **exocytosis**, vesicles containing substances fuse with the plasma membrane. The contents are then released to the exterior of the cell.



Methods of Transport, Energy Requirements, and Types of Material Transported

Transport Method	Active/Passive	Material Transported
Diffusion	Passive	Small-molecular weight material
Osmosis	Passive	Water
Facilitated transport/diffusion	Passive	Sodium, potassium, calcium, glucose
Primary active transport	Active	Sodium, potassium, calcium
Secondary active transport	Active	Amino acids, lactose
Phagocytosis	Active	Large macromolecules, whole cells, or cellular structures
Pinocytosis and potocytosis	Active	Small molecules (liquids/water)
Receptor-mediated endocytosis	Active	Large quantities of macromolecules

Take Home

1. Small nonpolar molecules can diffuse directly across the plasma membrane down their concentration gradient.
2. Facilitated diffusion uses membrane channels (channels and carriers) to let substances diffuse down their concentration gradients.
3. Water moves into and out of the cell through special channels called aquaporins. Cells are very susceptible to changes in the tonicity of their environment. Describe how cells react to isotonic, hypertonic and hypotonic solutions.
4. Cells establish a membrane potential by regulating the concentration of K+ and Na+ ions inside and outside the cell. This process requires energy.
5. Cells use active transport to move molecules against their concentration gradients. Describe the mechanisms.
6. Bulk transport moves large molecules into and out of the cell by endocytosis and exocytosis.